Practitioner's Docket No. MCA-449 PC/US

CHAPTER II

Preliminary Classification:
Proprosed Class:
Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.' " M.P.E.P. Section 601, 7th ed.

TRANSMITTAL LETTER TO THE UNITED STATES ELECTED OFFICE (EO/US)

(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

PCT/US99/28501	02 December 1999	03 December 1998
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED

FILTRATION CARTRIDGE AND PROCESS FOR FILTERING A SLURRY
TITLE OF INVENTION

Stephen PROULX, George PERIVOLOTIS, Zhenwu LIN, Gregory STRAEFFER, George A. GAGNE, Kenneth KING and Ralph J. STANKOWSKI
APPLICANT(S)

CERTIFICATION UNDER 37 C.F.R. SECTION 1.10*
*(Express Mail label number is **mandatory**.)*
(Express Mail certification is optional.)

I hereby certify that this correspondence and the documents referred to as attached therein are being deposited with the United States Postal Service on this date 8/30/01, in an envelope as "Express Mail Post Office to Addressee," Mailing Label Number EL 760376813US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Noreen Buckley
(type or print name of person mailing paper)

Signature of person mailing paper

WARNING: *Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. Section 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.*

****WARNING:*** *Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. Section 1.10(b).*
*"Since the filing of correspondence under [Section] 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition.' Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

Box PCT
Assistant Commissioner for Patents
Washington D.C. 20231
ATTENTION: EO/US

NOTE: *To avoid abandonment of the application, the applicant shall furnish to the USPTO, not later than 20 months from the priority date: (1) a copy of the international application, unless it has been previously communicated by the International Bureau or unless it was originally filed in the USPTO; and (2) the basic national fee (see 37 C.F.R. Section 1.492(a)). The 30-month time limit may not be extended. 37 C.F.R. Section 1.495.*

WARNING: *Where the items are those which can be submitted to complete the entry of the international application into the national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. Section1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing - See 37 C.F.R. Section 1.8.*

NOTE: *Documents and fees must be clearly identified as a submission to enter the national state under 35 USC 371 otherwise the submission will be considered as being made under 35 U.S.C. Section 111. 37 C.F.R. Section 1.494(f).*

1. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. 371:

   a. [X] This express request to immediately begin national examination procedures (35 U.S.C. Section 371(f)).

   b. [X] The U.S. National Fee (35 U.S.C. Section 371(c)(1)) and other fees (37 C.F.R. Section 1.492) as indicated below:

2.Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
[ ]*	TOTAL CLAIMS	33- 20 =	13	x $ 18.00 =	$234.00
	INDEPENDENT CLAIMS	2- 3 =		x $ 80.00 =	
	MULTIPLE DEPENDENT CLAIM(S) (if applicable) + $270.00				$ 270.00
BASIC FEE**	[ ] U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in Section 1.482 has been paid on the international application to the U.S. PTO: [ ] and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(2) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 C.F.R. Section 1.492(a)(4)) ..... $100.00 [ ] and the above requirements are not met (37 C.F.R. Section 1.492(a)(1)) ..... $690.00 [X] U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in Section 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in Section 1.445(a)(2) to the U.S. PTO: [ ] has been paid (37 C.F.R. 1.492(a)(2)) ..... $710.00 [ ] has not been paid (37 C.F.R. 1.492(a)(3)) ..... $1,000.00 [X] where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 C.F.R. Section 1.492(a)(5)) $860.00				$860.00
				Total of above Calculations	=$1,364.00
SMALL ENTITY	Reduction by 1/2 for filing by small entity, if applicable. Affidavit must be filed. (note 37 C.F.R. Sections 1.9, 1.27, 1.28)				-
				Subtotal	
				Total National Fee	$1,364.00
	Fee for recording the enclosed assignment document $40.00 (37 C.F.R. 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				$ 40.00
TOTAL				Total Fees enclosed	$1,404.00

* See attached Preliminary Amendment Reducing the Number of Claims.

i. [X] A check in the amount of $1,404.00 to cover the above fees is enclosed.

ii. [ ] Please charge Account No. _____ in the amount of $ _____.
A duplicate copy of this sheet is enclosed.

** *WARNING:* *"To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: * * * (2) the basic national fee (see Section 1.492(a)). The 30-month time limit may not be extended." 37 C.F.R. Section 1.495(b).*

WARNING: *If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. Section 1.495(b)(2). The payment of the surcharge set forth in Section 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in Section 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of Section 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.*

3. [X] A copy of the International application as filed (35 U.S.C. Section 371(c)(2)):

NOTE: *Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36. See item 14c below.*

a. [ ] is transmitted herewith.
b. [ ] is not required, as the application was filed with the United States Receiving Office.
c. [X] has been transmitted
   i. [X] by the International Bureau.
   Date of mailing of the application (from form PCT/IB/308): 08 June 2000.
   ii. [ ] by applicant on _____.
   Date

4. [X] A translation of the International application into the English language (35 U.S.C. Section 371(c)(2)):
a. [ ] is transmitted herewith.
b. [X] is not required as the application was filed in English.
c. [ ] was previously transmitted by applicant on _____.
   Date
d. [ ] will follow.

5. [X] Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. Section 371(c)(3)):

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. Section 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under Section 1.121. In many cases, filing an amendment under Section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

a. [ ] are transmitted herewith.
b. [ ] have been transmitted
   i. [ ] by the International Bureau.
   Date of mailing of the amendment (from form PCT/IB/308): _____.
   ii. [ ] by applicant on _____.
   Date
c. [X] have not been transmitted as
   i. [X] applicant chose not to make amendments under PCT Article 19.
   Date of mailing of Search Report (from form PCT/ISA/210): May 16, 2000.
   ii. [ ] the time limit for the submission of amendments has not yet expired. The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.

6. [X] A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. Section 371(c)(3)):
a. [ ] is transmitted herewith.
b. [ ] is not required as the amendments were made in the English language.
c. [X] has not been transmitted for reasons indicated at point 5(c) above.

7. [X] A copy of the international examination report (PCT/IPEA/409)
[X] is transmitted herewith.
[ ] is not required as the application was filed with the United States Receiving Office.

8. [X] Annex(es) to the international preliminary examination report
a. [X] is/are transmitted herewith.
b. [ ] is/are not required as the application was filed with the United States Receiving Office.

9. [X] A translation of the annexes to the international preliminary examination report
a. [ ] is transmitted herewith.
b. [X] is not required as the annexes are in the English language.

10. [X] An oath or declaration of the inventor (35 U.S.C. Section 371(c)(4)) complying with 35 U.S.C. 115

a. [ ] was previously submitted by applicant on _____.
Date

b. [X] is submitted herewith, and such oath or declaration

i. [ ] is attached to the application.

ii. [X] identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. Section 1.70.

c. [ ] will follow.

Other document(s) or information included:

11. [X] An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):

a. [X] is transmitted herewith.

b. [ ] has been transmitted by the International Bureau.
Date of mailing (from form PCT/IB/308): _____.

c. [ ] is not required, as the application was searched by the United States International Searching Authority.

d. [ ] will be transmitted promptly upon request.

e. [ ] has been submitted by applicant on _____.
Date

12. [X] An Information Disclosure Statement under 37 C.F.R. Sections 1.97 and 1.98:

a. [ ] is transmitted herewith.
Also transmitted herewith is/are:
[ ] Form PTO-1449 (PTO/SB/08A and 08B).
[ ] Copies of citations listed.

b. [X] will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. Sections 371(c).

c. [ ] was previously submitted by applicant on _____.
Date

13. [X] An assignment document is transmitted herewith for recording.

A separate [ ] "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or[X] FORM PTO 1595 is also attached.

_____
_____
_____

14. [X] Additional documents:
    a. [ ] Copy of request (PCT/RO/101)
    b. [X] International Publication No. WO 00/32290
        i. [ ] Specification, claims and drawing
        ii. [ ] Front page only
    c. [ ] Preliminary amendment (37 C.F.R. Section 1.121)
    d. [ ] Other

_____
_____
_____

15. [X] The above checked items are being transmitted
    a. [ ] before 30 months from any claimed priority date.
    b. [X] after 30 months.

16. [ ] Certain requirements under 35 U.S.C. 371 were previously submitted by the applicant on _____, namely:

_____
_____
_____

AUTHORIZATION TO CHARGE ADDITIONAL FEES

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claims are authorized.*

NOTE: *"A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under Section 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in Section 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. Section 1.136(a)(3).*

NOTE: *"Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. Section 1.26(a).*

[X] The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 501-908.

[X] 37 C.F.R. Section 1.492(a)(1), (2), (3), and (4) (filing fees)

WARNING: *Because failure to pay the national fee within 30 months without extension (37 C.F.R. Section 1 495(b)(2)) results in abandonment of the application, it would be best to always check the above box.*

[X] 37 C.F.R. Section 1.492(b), (c) and (d) (presentation of extra claims)

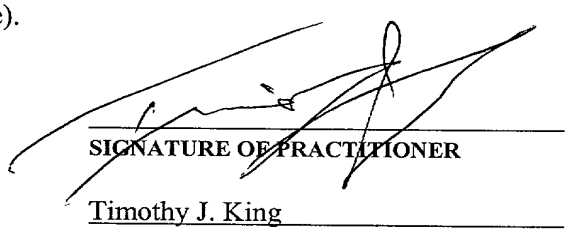
NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. Section 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.

[X] 37 C.F.R. Section 1.17 (application processing fees)
[X] 37 C.F.R. Section 1.17(a)(1)-(5)(extension fees pursuant to Section 1.136(a).
[ ] 37 C.F.R. Section 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. Section 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. Section 1.311(b).

NOTE: 37 C.F.R. 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. Section 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

[ ] 37 C.F.R. Section 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).



SIGNATURE OF PRACTITIONER

Reg. No.: 38,204

Tel. No.: (781) 533-2522

Customer No.:

29621
PATENT TRADEMARK OFFIC

Timothy J. King
(type or print name of practitioner)
Mykrolis Corporation
One Patriots Park
P.O. Address

Bedford, MA 01730

FILTRATION CARTRIDGE AND PROCESS FOR FILTERING A SLURRY

The present invention relates to a filter and a process for filtering particle containing or slurry like materials. More particularly, it relates to a depth filter and process for filtering slurries and compositions containing particles and/or gels such as CMP (chemical-mechanical planarization) slurries, photoresist chemicals and biological fluids such as transgenic milk or serum, blood and fermentation broths.

Background of the Invention

A fluid composition containing a particulate solid component is referred to in the art as a "slurry". The solid component can be any of a variety of materials including solid particles, cell components, flocculating agents, gel particles or the like. These are found in many applications including photoresist chemicals, biopharmaceutical products and abrasive materials for the semiconductor industry. Photoresist chemical compositions often contain gels and agglomerates of gels which are formed from the photoresist chemical due to shear, shock or age of the chemicals. Such gels and agglomerates need to be removed prior to using these chemical compositions. Biopharmaceutical liquid compositions such as cell broths, fermentation liquids, transgenic milks and other transgeric liquids, blood, blood fractions or other bacterial or animal fluids or secretions, contain whole cells, cell components, fats and other solids which need to be removed to in order to further process and recover desired components of these compositions.

Of particular interest are slurry compositions utilized in CMP to polish wafers in VLSI and ULSI integrated circuit devices. High pH silica CMP slurries are utilized to polish dielectric and polysilicone layers. In addition, acidic silica and alumina or metal/metal oxide abrasive based slurries are

utilized to polish metal interconnects. The CMP process uses submicron (30-500 nm) abrasive particles at a typical concentration of 1-30% by weight particles.

The typical specification for commercial CMP slurries includes percent solids, pH, specific gravity, mean particle size and general (bulk) particle size distribution. However, a small number of "large" particles (>1 um) have been found which fall outside of the specified size distribution. These particles can be aggregates, agglomerates or gels and may be formed from agglomeration, settling, system or pH shock or local drying of slurry. The large particles and agglomerates can cause microscratches and they, together with the gels cause other defects on planarized wafer surfaces during CMP processing. Slurry filtration to remove these relatively large particles has proven to be beneficial in reducing wafer defects and increasing yields in CMP processes. At the present time a wide variety of filter cartridge constructions are utilized to purify fluids. These cartridge constructions are designed to remove solids and colloidal particles as well as microorganisms. The basic two separate and distinct types of cartridges used in filtration of gases and liquids are depth filters (typically wound) and surface or screen filters (usually pleated). A depth filter is primarily used to remove most of the contaminants and particles. It is typically utilized upstream of a surface or screen filters. The most important properties for a depth filter are its "dirt holding capacity" or throughput, pressure drop and retention. The filter design allows contaminants and particles to be trapped in stages within the depth of the filter due to the construction of the multiple layers of various media types. A wound depth filter has multiple layers with the most open media (largest micron retention rating), i.e., largest pore size usually the outermost layer, adjacent the liquid inlet with the tightest media at the core adjacent the liquid outlet will have the least amount of surface area due to the smallest diameter around which it is wrapped. The layer at the core contributes to most of the pressure drop of the cartridge because the media has the highest pressure drop and the least amount of filtration surface area. Likewise, this layer will significantly

reduce the capacity of the filter due to both the low filtration surface area and the smallest micron retention rating.

Presently available depth filters are positioned within a housing, spaced apart from the interior housing walls thereby to form a void volume upstream of the depth filter. This spacing is effected to permit either the introduction of a fluid feed into the entire filter or the removal of the entire permeate from the filter. If this spacing were not maintained, fluid flow through the filter can be severely restricted. As a result, a relatively large high fluid hold-up volume occurs in a conventional filter unit. A depth filter construction utilizing such a spacing also is disadvantageous for filtering a slurry since the particles in the slurry can settle out of the slurry on and within the filter. This results in rapid plugging of the filter, particularly at low flow rate point of use applications.

Depth filters comprising a relatively deep bed of filter material are undesirably compressible under the pressure of fluid entering the filter bed. Filter bed compressibility depends upon the type of filter, retention characteristics of the filter and thickness of the depth filter. For example, thick filter beds are more compressible than thinner filter beds. When the filter bed is compressed, void volume is reduced and, the probability of plugging is increased. This results in an undesirably short useful life of the filter. In addition, compression of the filter bed requires that the pressure of feed fluid be increased in order to maintain desired fluid through put rates. These conditions of increased pressure increase the probability that undesirable channeling of fluid in the space between the filter housing and the filter bed results. Such channeling is undesirable since the channeled fluid does not pass through the filter bed and undesirably large particles are not removed from the fluid.

A surface or screen filter will retain virtually 100% of the particles or contaminants for which it is rated. The media used in surface or screen filter typically has a high pressure drop and low "dirt holding capacity" or throughput because of its high retention efficiency. The media normally used in a surface filter comprises glass or polymeric microfibers. Particles are

retained by size exclusion primarily on the surface of the screen filter rather than within the depth of the filter. Particles smaller than the controlled pore size tend to be trapped within the media of the surface filter. However, as a result of the controlled pore structure, they provide more predictable filtration than depth filters. Screen filters are not useful for filtering a slurry since they will become plugged quickly by the solid particles and gels in the slurry.

Accordingly, it would be desirable to provide a filter cartridge including a depth filter for filtering a slurry which effectively removes undesirably large solid particles and gels. In addition, it would be desirable to provide such a filter cartridge which permits passage there through of particles in the slurry within a desired particle size range. Furthermore, it would be desirable to provide such a filter cartridge wherein compression of the depth filter is controlled to substantially prevent compression of the depth filter and channeling of the slurry being filtered.

Summary of the Invention

The present invention comprises a process for filtering a slurry and a filter cartridge construction for filtering a slurry having a filtration medium formed of a depth filter such as a cylindrical seamless fibrous depth filter comprising a nonwoven fibrous mass, woven fibers, a plurality of nonwoven fibrous layers of a fibrous felt or the like or a wound depth filter retained within a housing substantially free of an open void volume upstream of the depth filter which causes separation of solid particles from a slurry being filtered.

The filtration medium is preferably divided into a plurality of depth filter segments by spacers having an open central portion. The spacers serve to divide the depth filter medium and to allow fluid to pass there through. By utilizing the spacers, the compressibility of the filtration medium is substantially reduced. The spacers also prohibit channeling along the inner wall of the housing during filtration. By the term "open void volume" as used herein is meant a volume free of a material including materials for forming a

The present invention provides a filter cartridge as defined in claim 1 and a process for filtering a slurry as defined in claim 16. Preferred embodiments AMENDED SHEET ...ridge and of the process are defined in the dependent ...

depth filter and is not meant to include the void volume normally encountered in conventional filter-housing construction.

One end of the cartridge of this invention is sealed with a cap having a fluid inlet while the opposing end is sealed with a cap having a fluid outlet. When the filtration medium is a wound depth filter, it is positioned around a core which extends substantially the length of the cartridge. When the depth filter comprises a nonwoven fibrous mass, it is compressed to effect the desired percent retention efficiency of the mass. The depth filter also can comprise a layered filter construction having a plurality of filtration media, each having a controlled percent retention rating. The layers of the depth filter are formed of felt layers, of wound or layered flat filtration sheets, woven fibers or of a fibrous mass of nonwoven polymeric fibers secured together by mechanical entanglement or interweaving of the fibers. The filter cartridges of this invention retain undesirably large particles and gel particles which permitting passage there through of particles of a slurry having a size within a desired size range.

It is an object of the present invention to provide a filter cartridge for filtering a slurry composition which comprises a hollow housing having a first end including an inlet and a second end including an outlet, said hollow housing being filled with a depth filter and being free of an open void volume upstream of said depth filter.

It is another object of the present invention to provide a filter cartridge for filtering a slurry composition which comprises a hollow housing having a first end including an inlet and a second end including an outlet, said hollow housing being filled with a depth filter and being free of an open void volume upstream of said depth filter and said depth filter is formed of segments separated by annular spacers.

It is another object of the present invention to provide a filter cartridge for filtering a slurry composition which comprises a hollow housing having a first end including an inlet and a second end including an outlet, said hollow housing being filled with a depth filter and being free of an open void volume upstream of said depth filter, said depth filter is formed of segments separated

by annular spacers, and the inner walls of the housing adjacent the ends of the housing have one or more slots formed therein, the end caps contain one or more C-rings and the C-rings secure the end caps to the housing by fitting at least partially into the one or more slots of the housing.

Brief Description of the Drawings

Fig. 1A is a cross-sectional view of the filter cartridge of this invention.

Fig. 1B is a cross-sectional view of another embodiment of the filter cartridge of this invention.

Fig. 2 is a cross-sectional view of the filter cartridge of the prior art.

Fig. 3 is a partial cross-sectional view of one end cap embodiment for the depth filter of this invention.

Fig. 3a is a top view of the element of the end cap of Fig. 3.

Fig. 4 is an isometric view of the end cap of Fig. 3.

Fig. 5 is a partial cross-sectional view of one end cap embodiment for the depth filter of this invention.

Fig. 6 is a partial cross-sectional view of one end cap embodiment for the depth filter of this invention.

Fig. 7 is a partial cross-sectional view of one end cap embodiment for the depth filter of this invention.

Fig. 8 is a partial cross-sectional view of one end cap embodiment for the depth filter of this invention.

Fig. 9 is a partial cross-sectional view of one end cap embodiment for the depth filter of this invention.

Fig. 10 is a graph showing the test results of Example 1.

Description of the Specific Embodiments

The present invention provides a filter cartridge construction which comprises (1) a depth filter comprising either (a) a wound depth filter, (b) a stack of depth filters or (c) a cylindrical seamless fibrous depth filter formed from a fibrous mass of fibers. The depth filter has a thickness in the direction

of fluid flow there through of between about 1 and about 18 inches, preferably between about 3 and about 12 inches to attain effective retention of undesirably large particles while permitting passage there through of particles within a desired size range.

The depth filter preferably includes a plurality of annular spacers positioned within the depth filter in order to segment the depth filter into segments. The ratio of depth filter segment thickness to spacer thickness is between about 1.1: 1 and about 5:1, preferably is between about 1.5: 1 and about 3:1. The spacer comprises an annular ring with an open central portion. The spacer has a thickness between about 0.01 and about 0.12 inches, preferably between about 0.01 and about 0.07 inches. The spacers provide a means for substantially reducing the compressibility of the depth filter during use under the pressure of feed fluid. A spacer providing a depth filter segment to spacer ratio of greater than about 5 is generally ineffective for reducing compressibility of the depth filter. A spacer having a thickness greater than about 0.12 inches is undesirable since it will promote separation of solid particles from a slurry being filtered due to a large space between filter medium segments. In this instance, one may insert or bond a piece of filtration medium into the opening of the spacer to form an essentially continuous medium subject to the flow of fluid through out the length of the filter.

Alternatively, one may eliminate the use of the spacers, especially in shorter lengthed devices or with relatively rigid filtration media or with media used in the form of a wound depth filter or a cylindrical seamless fibrous depth filter formed from a fibrous mass of fibers. However, even here the use of spacers are desirable for the advantages outlined above.

The depth filter of this invention preferably comprises one or a plurality of media each having the same or different micron retention size in the form of a stack of depth filters. In one embodiment, the depth filter comprises a plurality of media (layers) each having a different micron retention size so that the retention of the media layers is greatest adjacent the fluid outlet from the cartridge. Micron retention size can be varied by controlling the fiber size

and/or fiber spacing. Thus, large particles will be retained adjacent the feed inlet and progressively smaller particles will be retained as the feed passes through the filter cartridge. The permeability or retention of the media layers is controlled so that particles in the slurry within a desired particle range pass through the cartridge and through the outlet. It has been found, in accordance with this invention, that the useful life of the cartridge of this invention is at least about 50 percent longer, preferable at least about 200 percent longer than a prior art filter cartridge having a void volume in a housing positioned upstream a depth filter positioned within the housing. Thus, the filter cartridge of this invention permits the use of fewer cartridges for a particular application and cost as compared to the filter cartridges of the prior art. Percent retention efficiency and Beta Ratio are measures of the ability of the ridge to capture and retain particles. The Beta Ratio concept was introduced by the Fluid Power Research Center (FPRC) at Oklahoma State University (OSU) in 1970. Originally developed for use in hydraulic and lubricating oil filters, the test has been adapted by many cartridge manufacturers to measure and predict the cartridge filter performance in aqueous based fields. Beta Ratio is defined by the FPRC as the number of particles greater than a given size (x) in the feed, divided by the number of particles greater than the same size in the effluent. Both percent retention efficiency and Beta Ratio values are calculated for specific particle size ranges.

The following equations showed the relationship between Beta Ratio and percent retention efficiency:

$$\% \text{ Retention Efficiency} = \frac{\text{Number of feed particles-Number of effluent particles (size X)}}{\text{Number of feed particles (size X)}} \times 100$$

$$\text{Beta Ratio (B)} = \frac{\text{Number of feed particles (size X)}}{\text{Number of effluent particles (size X)}}$$

$$\% \text{ Retention Efficiency} = \frac{B-1}{} \times 110$$

B

$$\text{Beta Ratio (B)} = \frac{X}{100 - \%\ \text{Retention Efficiency}}$$

In the filter cartridge of this invention, the filter medium of the depth filter having the largest micron retention is preferably positioned adjacent an inlet to the filter cartridge. The filter media of the depth filter having the smallest micron retention is preferably positioned adjacent the outlet from the filter cartridge. The micron retention characteristics of a filter can be varied by varying the diameter of fibers used to form the filter and/or the extent of compression of the fibers such as by winding a filter medium sheet tighter or looser around a core. A tighter wound filter medium gives a higher percent retention efficiency. The intermediate filter media are positioned according to percent retention of efficiency so that incoming slurry is passed sequentially through the filter media having progressively smaller micron retention and lastly through the filter media having the smallest micron retention. Thus the overall filter cartridge presents a percent retention efficiency which comprises a progressive gradient from the inlet to the outlet wherein the percent retention efficiency progressively increases.

Representative media useful for forming the depth filter include the fiber of polyolefins such as polyethylene, polypropylene, cellulose including cellulose/diatomaceous earth or silica blends as are available from Millipore Corporation of Bedford, Massachusetts under the brandname MILLISTACK+, cellulose derivatives such as cellulose acetate, cotton, polyamides, polyesters, fiberglass, polytetrafluoroethylene (PTFE), fluoropolymers such as PFA, MFA and FEP or the like.

The fibrous depth filter is free of seams and is formed of fibers which produce a fibrous mass of fibers. This embodiment of the depth filter can be characterized by a gradation of micron retention characteristics throughout its thickness in the direction of fluid flow through the depth filter. This gradation can be achieved either by varying the void volume of the cylindrical fibrous

depth filter medium as a function of thickness in the direction of fluid flow through the filter or by maintaining a constant volume and varying the size of the fibers as a function of depth filter thickness in the direction of fluid flow through the depth filter. In either embodiment all that is necessary is that the gradation of micron retention characteristics is produced. The gradation is effected such that the slurry to be filtered first encounters a layer of the depth filter having a largest micron retention characteristics (i.e. largest pores) and encounters layers having progressively smaller micron retention characteristics (i.e. smallest pores) prior to being directed through the outlet. The seamless cylindrical fibrous depth filter can be formed by any conventional means such as is disclosed in U.S. patents 3,933,557; 4,032,688; 4,726,901 or 4,594,202 which are incorporated herein by reference.

Representative slurries which can be filtered in accordance with this invention include CMP slurries such as silica-based slurries, alumina-based slurries, ceria-based slurries, diamond-based slurries, manganese dioxide-based slurries, titanium and other metal or metal oxide slurries. Additionally, representative biological-type slurries in which the filter of this invention can be used include cell broths whether containing whole cells or ruptured cells or cellular components, fermentation products, a transgeric liquid such as transgeric milk, blood, a blood fraction or other slurries which contain large components which need to be separated from smaller components.

In one method for forming a cylindrical seamless fibrous depth filter, for example, a molten thermoplastic composition is spun from a multiplicity of orifices arranged at an angle to a rotating mandrel. The orifices are positioned at a plurality of distances from the mandrel. Gas is directed at the orifices in a direction generally in the direction of projection of the fibers from the orifices to attenuate and disrupt the fibers into discrete lengths. The fibers are collected and wound on the mandrel to form a generally spiraling wound cylindrical layer of randomly intertwined spun fibers and to form the seamless cylinder which can be removed from the mandrel. Micron retention characteristics for a given layer can be controlled by controlling the rate of exit

of fibers from a particular set of orifices which produce a given layer, thereby to control the void volume in that layer.

In a second method, the cylindrical seamless fibrous depth filter is formed in a manner whereby the void volume throughout the filter thickness in the radial direction is essentially constant. The desired micron retention characteristic gradation is achieved by varying the size of the fibers throughout the cylindrical fibrous depth filter in the radial direction. The smallest fibers produce a layer having the smallest micron retention characteristics while the largest fibers produce a layer having the largest micron retention characteristics. The fibers are formed by extruding a molten thermoplastic composition from a fiberizing die. The fibers are attenuated by a gas stream directed to a rotating reciprocating mandrel. The fibers are cooled prior to their collection on the mandrel to a temperature below which the fibers bind to each other to substantially eliminate fiber to fiber bonding. The cooled fibers are collected on the mandrel and are subjected to a compression force to effect a substantially constant void volume through the thickness of the cylindrical seamless fibrous depth filter in the radial direction. The cylindrical and fibers depth filter can be formed on the pleated on a core.

Typically, the void volume of the cylindrical fibrous depth filter ranges between about 60 and 95 percent and varies no more than about 1 to 2 percent. Typically the fibers range in diameter between about 1.6 and 16 micrometers. The compositions for forming the depth filter of this invention also can have specific properties either inherent or added such as hydrophilicity, hydrophobicity, a positive or negative charge or the like. Charged media is particularly useful in the purification of products such as photochemicals including dye solutions, pigment disprsed fluids used in the manufacture of color filters for LCDs and in biological applications such as virus removal and protein separations.

The wound depth filter is formed by winding one or a plurality of filter sheets formed of fibers to form a joint generally cylindrical structure. The filter sheet or sheets have varying pore size such that the micron retention characteristic of a portion of the depth filter as a function of radial position

within or on the depth filter. The portion of the wound depth filter positioned adjacent an inlet to the filter cartridge including the wound depth filter has the largest micron retention characteristics while the portion of the wound depth filter having the smallest micron retention characteristics, i.e. the smallest pore size is positioned adjacent the outlet from the filter cartridge. Any intermediate portions of the wound depth filter are positioned according to pore size so that incoming slurry is passed sequentially through portions of the depth filter having progressively smaller micron retention characteristics and lastly through the portion of the filter having the smallest micron retention characteristics. Representative media useful for forming depth filters include the fibers set forth above for the cylindrical seamless fibrous filters.

The depth filter can be formed from one or a plurality of separate filter sheets by stacking the sheets within a housing in a manner such that an open volume within the housing upstream of the depth filter which would promote particle separations from a slurry is avoided. The filter sheet or sheets can have the same pore size or varying pore size such that the micron retention characteristic of a portion of the depth filter varies along the length of the housing. When utilizing sheets having varying pore size, the portion of the filter stack positioned adjacent an inlet to the filter cartridge preferably has the largest micron retention characteristics while the portion of the filter stack having the smallest micron retention characteristics, i.e. the smallest pore size is preferably positioned adjacent the outlet from the filter cartridge. Any intermediate portions of the filter stack are positioned according to pore size so that incoming slurry is passed sequentially through portions of the depth filter having progressively smaller micron retention characteristics and lastly through the portion of the filter having the smallest micron retention characteristics. Representative media useful for forming the filter stack include the fibers set forth above for the cylindrical seamless fibrous filters.

Referring to Fig. 1A and 1B, the filter cartridge 10 of this invention includes a housing 12 and end caps 14 and 16 which are sealed to housing 12 ~~and end caps 14 and 16 which are sealed to housing 12~~ by means of O-rings 18 and 20. The embodiment of Figure 1A contains the spacers while

the embodiment of Figure 1B does not. The end caps 14 and 16 can be attached to housing 12 by any conventional means such as by screwed onto or outside threaded surface of housing 12. End cap 14 is provided with an inlet 24 and end cap 16 is provided with an outlet 25. A plurality of stacks of filter sheets 28 are positioned within housing 12 separated by annular spacers 27 throughout the height of the housing 12 not occupied by end caps 14 and 16. Each of the sheets 28 comprises a filter medium as described above. The interior of housing 12 is a free of open volumes. That is, it is completely filled with the stack of filter sheets 28 separated by annular spaces 27 having an open central volume.

Referring to Fig. 2, the filter cartridge 30 of the prior art includes a housing 32 having an inlet 34 and an outlet 36. A filter cartridge 38 includes a depth filter 40 wound around a hollow core, an end cap 44 sealed to the core 42 and depth filter 40 and an outlet 46. Each of the sheets 48 comprises non-woven fibers as described above. The interior of housing 32 includes a void volume 31. When a slurry is filtered with this filter cartridge, the filter becomes plugged rapidly due to precipitation of particles from the slurry onto the exposed surface of the depth filter adjacent the open void volume 31.

Referring to Figs. 3, 3A and 4, a preferred end cap construction of this invention is shown. The end cap 50 includes two spring-loaded C-shaped rings 52 which are compressed to fit into slots 53 and 54. The O-ring 55 fits into slot 56. When the end cap 50 is positioned into housing 12, the C-rings 52 are allowed to expand into slots provided in housing 12 to be positioned as shown in Fig. 3. It is to be understood that a single C-shaped ring 52 can also be utilized in this preferred embodiment of the present invention. This C-ring construction provides excellent sealing within the housing to prevent leakage from the housing.

The end cap 51 includes an inner bottom surface 58 having ribs 60 which promotes substantially uniform distribution of incoming fluid feed over atop surface of the depth filter construction of this invention. The maximum height 61 of the ribs 60 is between about 0.25 and about 1.0 inches, preferably between about 0.25 and about 0.5 inches. This height is

sufficiently small as to prevent separation of solid particles from a slurry to be filtered while promoting the desired uniform distribution of incoming slurry feed.

Referring to Fig. 5 a second preferred end cap construction of this invention is shown. The end cap 70 is formed of two pieces 71 and 72 is attached to the top of the filter housing 73 rather than the interior of the housing as is shown in the embodiment of Figures 1A and 1B. One spring-loaded C-shaped ring 74 is compressed to fit into slot 75 formed on the inner surface of the housing 73 adjacent an end. The inner cap piece 71 is retained within the bore of the housing below the slot 75 by the ring 74. It also has an O-Ring 76 which fits into slot 77 to prevent any leakage from the interior of the housing. Outer end cap piece 72 is retained to the inner piece 71 by a snap fit 78 between the two pieces. After the inner end cap piece 71 is positioned into housing 73, the C-ring 74 is placed into the housing and allowed to expand into slot 75 provided in housing 73 to be positioned as shown in Fig. 5. It is to be understood that a single C-shaped ring 74 is preferably used in this device although two may be used or one ring may be formed as two halves and used instead. This C-ring construction provides excellent sealing within the housing to prevent leakage from the housing.

The inner end cap piece 71 includes an inner bottom surface 79 having ribs 80 which compress and promote a good seal between the media 81 and the inner cap piece while providing a small space for the substantially uniform distribution of incoming fluid feed over atop surface of the depth filter construction of this invention. The maximum height of the ribs 80 is between (about 6.349 mm and about 25.39 mm) (about 0.25 and about 1.0 inches), preferably between (about 6.349 mm and about 12.69 mm) (about 0.25 and about 0.5 inches). This height is sufficiently small as to prevent separation of solid particles from a slurry to be filtered while promoting the desired uniform distribution of incoming slurry feed.

The outer cap piece 72 has an outer lip 82 which extends out over the outer diameter of the housing and along a portion of its side. It also may have a nib 83 which is made to fit between the inner wall of the housing and the upper leg 84 of the C-ring 74.

This end cap design provides several advantages. First it is simpler to manufacture and assemble. It reduces the potential for the media to be deformed (puckering or wrinkling of the upper layer of the media) during assembly which leads to fluid bypass. The nib 83 helps to prevent the cap assembly 70 from flexing when under pressure.

Fig 6 shows another end cap design of the present invention. In this embodiment, the end cap assembly 90 is again two pieces, 91 and 92. The housing 93 has an outwardly extending flange 94. The first end cap piece 91 is placed on top of the end of the housing 93 and flange 94 as shown and retained to the housing via a clamp or C-ring 95. The outer end cap piece 92 is snap fit or otherwise retained on to the inner cap piece 91. As can be seen the outer portion of the inner end cap piece 96 is a flange which is substantially co-extensive with the flange 94 of the housing 93. The design of this embodiment eliminates the need to machine the slot into the inner wall of the housing while providing the good seal and compressibility of the other embodiments.

Fig 7 shows another embodiment which is a variation of the embodiment of Fig 6. To the extent that the pieces represent the same item in both drawings, the same number has been used. The difference in this embodiment is that the outer edge 97 of the inner cap piece 91 is substantially equal to the inner diameter of the housing, but in no event is it greater than the inner diameter of the housing. It is still retained within the housing by the clamp or C-ring 95.

Fig 8 is a modification of Fig 5. In this embodiment, there is no nib as in Fig 5. Instead one relies upon a thicker, broader flange 100 on the c-ring 101 to hold the inner cap piece 102 within the housing 103 and to prevent any flexing of either the inner piece or outer cap piece 104 when under pressure. Additionally, ribs 105 extend downward from the outer cap piece 104 and touch the inner cap piece 102 providing additional strength and rigidity to the end cap design. Further the inner surface 106 of the inner cap piece 102 is formed as a series of fins rather than as a solid piece as was shown in other embodiments.

Fig 9 shows a modification of the design of Fig 8 where in the ribs 110 on the outer cap piece 111 do not touch the inner cap piece 112. The inner cap piece 112 is a solid piece unlike that of the embodiment of Figure 8.

Lastly, other embodiments can also be used to attach the end caps to the housing such screw threads formed on the housing and the end cap (not shown) or heat bonding the end caps to the housing (not shown). Any such design is acceptable so long as it forms a leak proof seal which is capable of compressing the depth media and which is capable of withstanding any pressure it may normally be subjected to.

Example 1

This example illustrates the use of the filter cartridge of this invention as shown in Fig. 1. The results are shown in Fig. 10. In Fig. 10, the filter cartridges of this invention are identified as "HD filters 1,2,3" and included 70 annular spacers separated by filter segments made of polypropiene melt-blown and spun-bond fibers having a height of between 0.10 and 0.18 with a total height of 9.1 inches. The control filters 1a and 1b had the following construction: spun-bond and melt-blown fibers formed into a series of sequentially tighter cohesive fabrics and wrapped around a perforated core. The control filter 2 had the following construction: spun-bond and melt-blown fibers formed into a series of sequentially tighter cohesive fabrics and wrapped around a perforated core.

A diluted silica slurry comprising 12 percent silica particles by weight was filtered through each of the filter cartridges. Control filter 2 was brought on line after filters 1a and 1b plugged.. Control filter 3 was brought on line after control filter 2 plugged. The slurry was circulated through the filters from a 20 gallon tank at a constant flow rate of 250 ml/min. The pressure drop across each filter was monitored to determine the extent of loading on the filter. When the initial control filter (1a and 1b) plugged, a second control filter (2) was brought on line to test against the filter of this invention. A third control filter (3) was brought on line after the second control filter was plugged.

As shown in Fig. 10, the depth filter construction of this invention have a useful life about 2.5 times the useful life of a conventional filter when filtering a slurry.

PCT/US99/28501
MILLIPORE CORPORATION et al.

New Claims

1. A filter cartridge for filtering a slurry composition which comprises

a hollow housing (12) having a first end including an inlet (24) and a second end including an outlet (25), said hollow housing (12) being filled with a depth filter (28) and being free of an open void volume upstream of said depth filter (28).

2. The filter cartridge of claim 1 wherein said depth filter is formed of segments (28), preferably separated by annular spacers (27).

3. The filter cartridge of claim 2 wherein said depth filter segments (28) comprise a wound depth filter comprising nonwoven fibers.

4. The filter cartridge of claim 2 wherein said depth filter segments comprise a stack of sheets (28) wherein each sheet (28) comprises nonwoven fibers.

5. The filter cartridge of claim 2 wherein said depth filter segments (28) comprise a fibrous mass of nonwoven polymeric fibers secured together by mechanical entanglement of the fibers.

6. The filter cartridge of claims 2 to 5 wherein the ratio of depth filter segment thickness to spacer thickness is from about 1.1:1 to about 5:1.

7. The filter cartridge of claim 6 wherein the ratio of depth filter segment thickness to spacer thickness is from about 1.5:1 to about 3:1.

8. The filter cartridge of any one of claims 1 to 7 wherein the housing (12) is free of an open void volume downstream of said depth filter (28).

9. The filter cartridge of any one of claims 1 to 8 wherein the depth filter (28) inserted into the housing (12) is precompressed into its final length.

10. The filter cartridge of any one of claims 1 to 9 further comprising end caps (14,16;50,51;70;90) secured to the ends of the housing (12;73;93) by a mechanical device.

11. The filter cartridge of claim 10 wherein the inner walls of the housing (12;73) adjacent the ends of the housing (12;73) have one or more slots formed therein, the end caps (14,16;50,51;70) contain one or more C-rings (52;74) and the C-rings (52;74) secure the end caps (14,16;50,51;70) to the housing (12;73) by fitting at least partially into the one or more slots of the housing (14,16;50,51;70).

12. The filter cartridge of claim 10 wherein the outer walls of the housing (93) adjacent the ends of the housing (93) have a flange (94) formed thereon and the end caps (90) are secured to the flange (94) by a C-ring (95).

13. The filter cartridge of claim 11 or 12 wherein the end caps (70;90) are formed of two or more pieces known as the inner end cap piece (71;91;102;112) and outer end cap piece (72;92;104;110) and at least the inner end cap piece (71;91;102;112) is secured by said to said housing.

14. The filter cartridge of claim 13 wherein the outer end cap piece (72;92;104;110) is secured to the inner cap piece (71;91;102;112).

15. The filter cartridge of any one of the preceding claims wherein the media has a surface treatment selected from the group consisting of hydrophobicity, hydrophilicity or a positive or negative charge.

16. A process for filtering a slurry which comprises

passing a slurry through a filter cartridge as defined in any one of claims 1 to 15, and

recovering a filtered slurry from said cartridge.

17. The process of claim 16 wherein said slurry is selected from the group consisting of a silica-based slurry, an alumina-based slurry, a ceria-based slurry, a diamond-based slurry, a MnO_2- based slurry, a cell broth, a photoresist chemical, a fermentation liquid, blood, a blood fraction and a transgenic liquid.

18. The process of claim 16 wherein said slurry is transgenic milk.

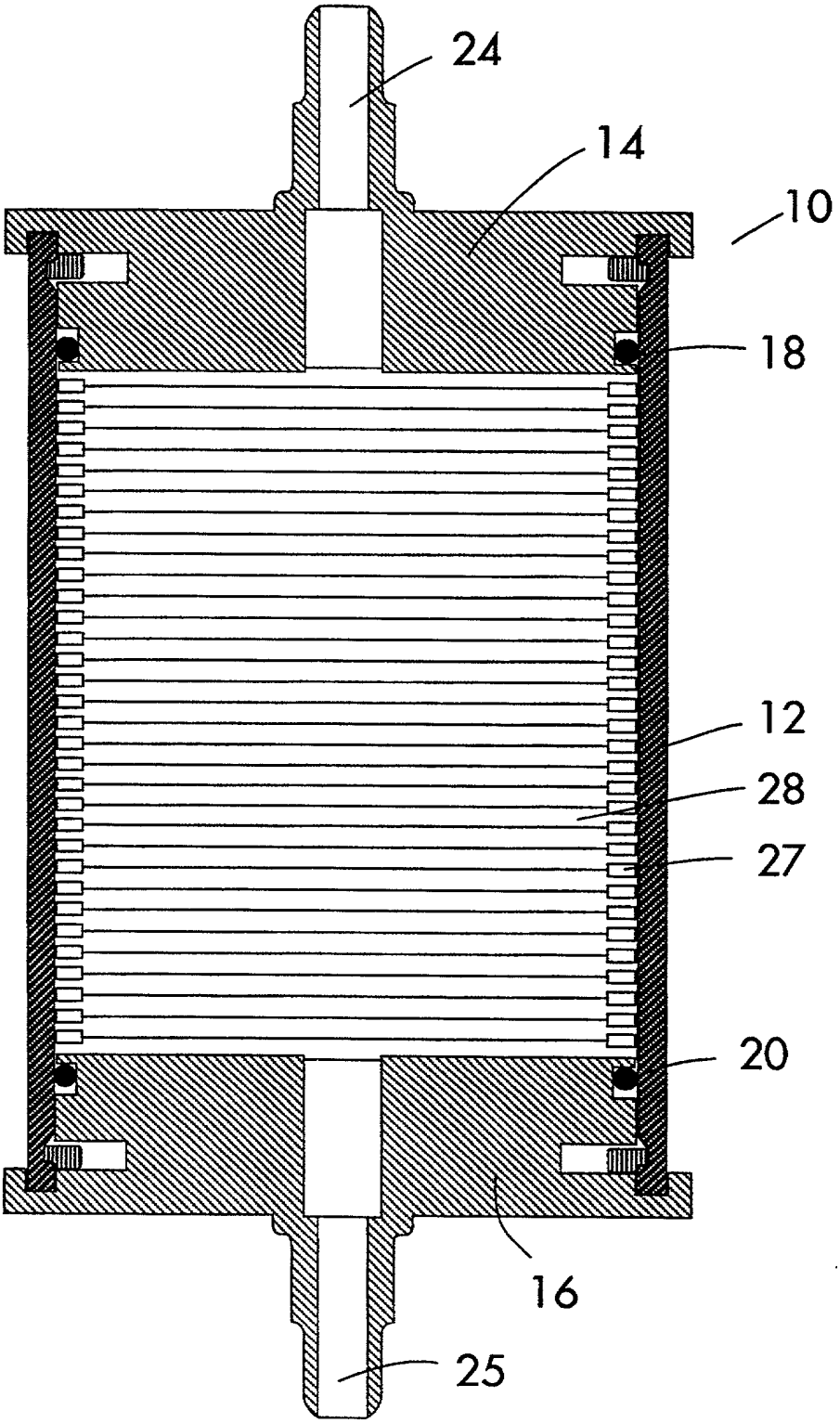


Figure 1A

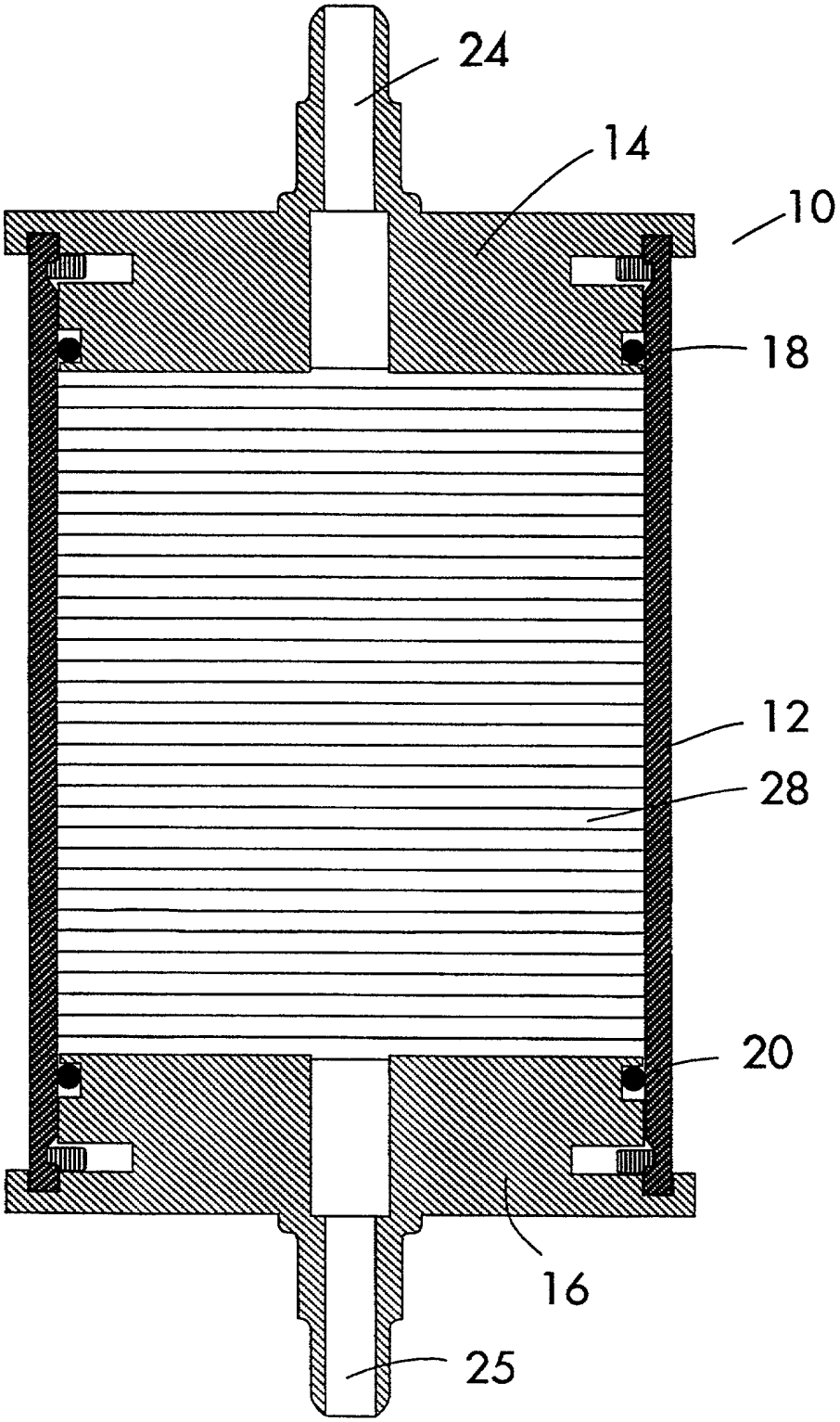


Figure 1B

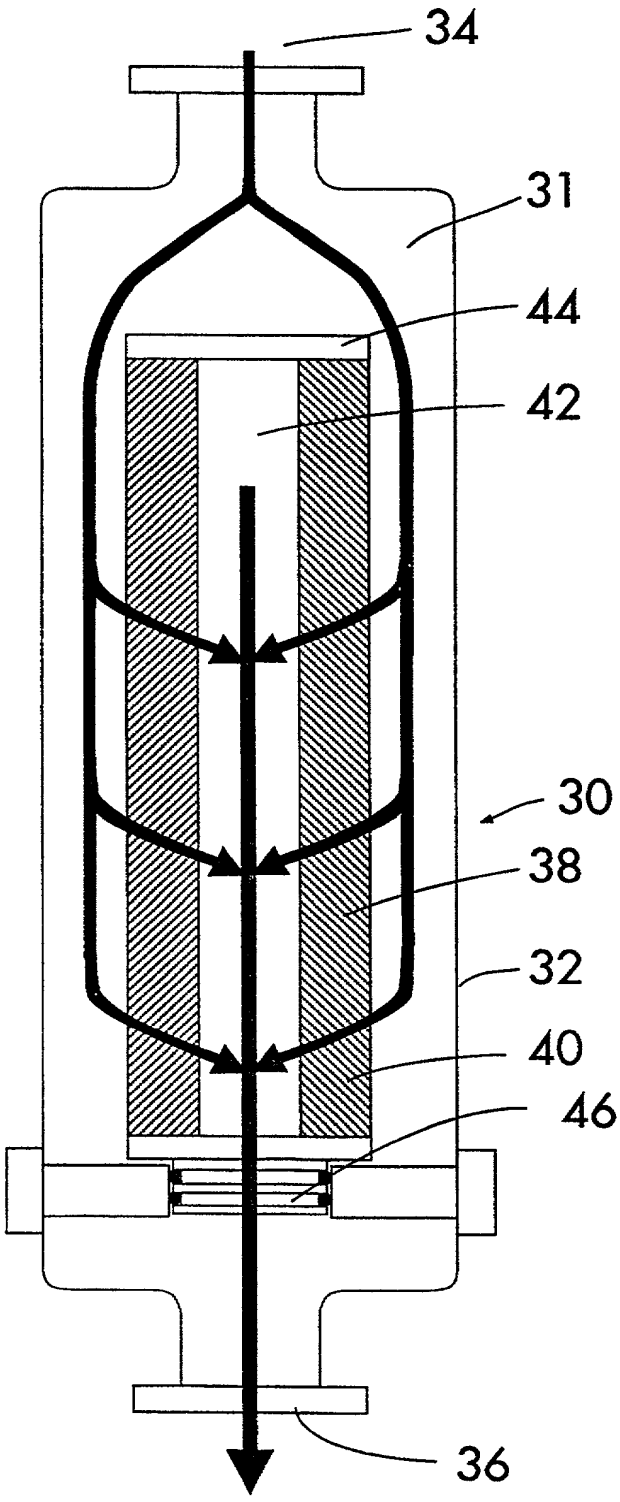


Figure 2
(prior art)

09/914994

09/913977

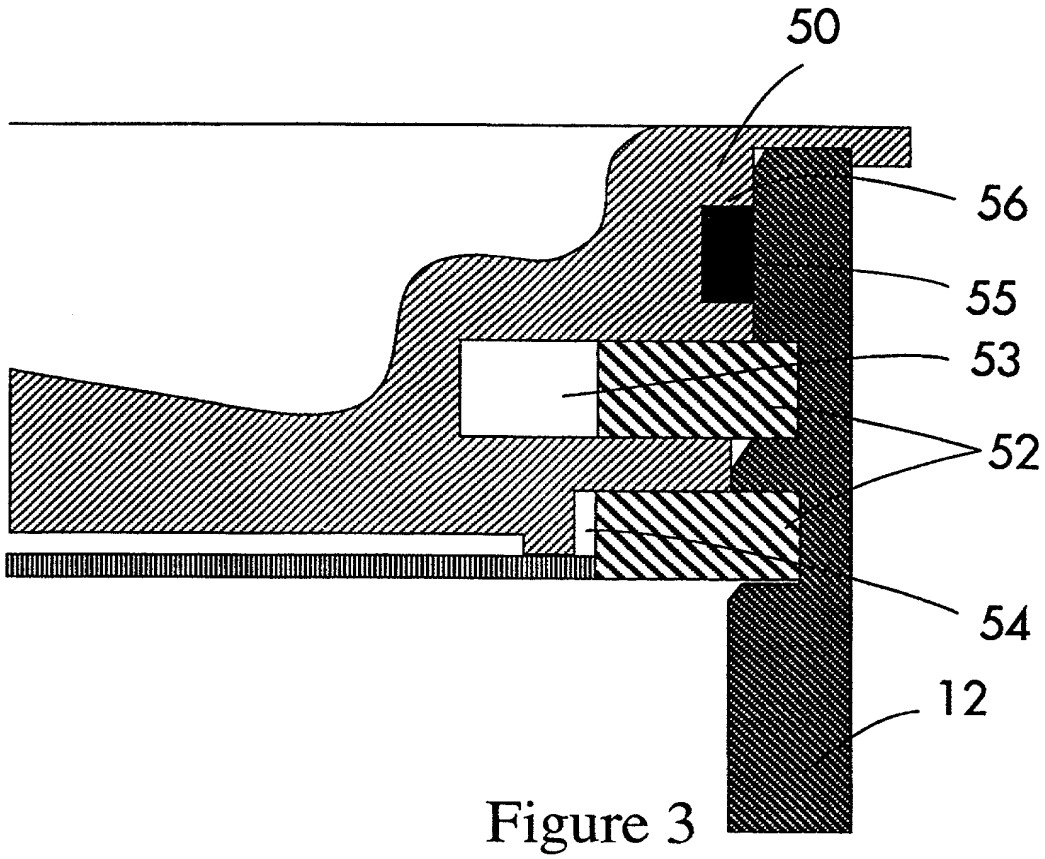


Figure 3

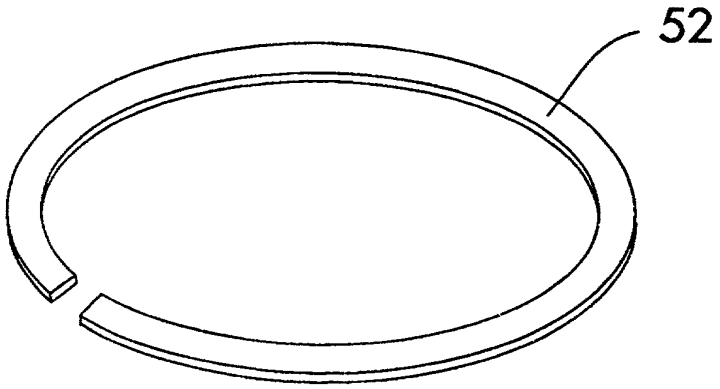


Figure 3A

09/913977

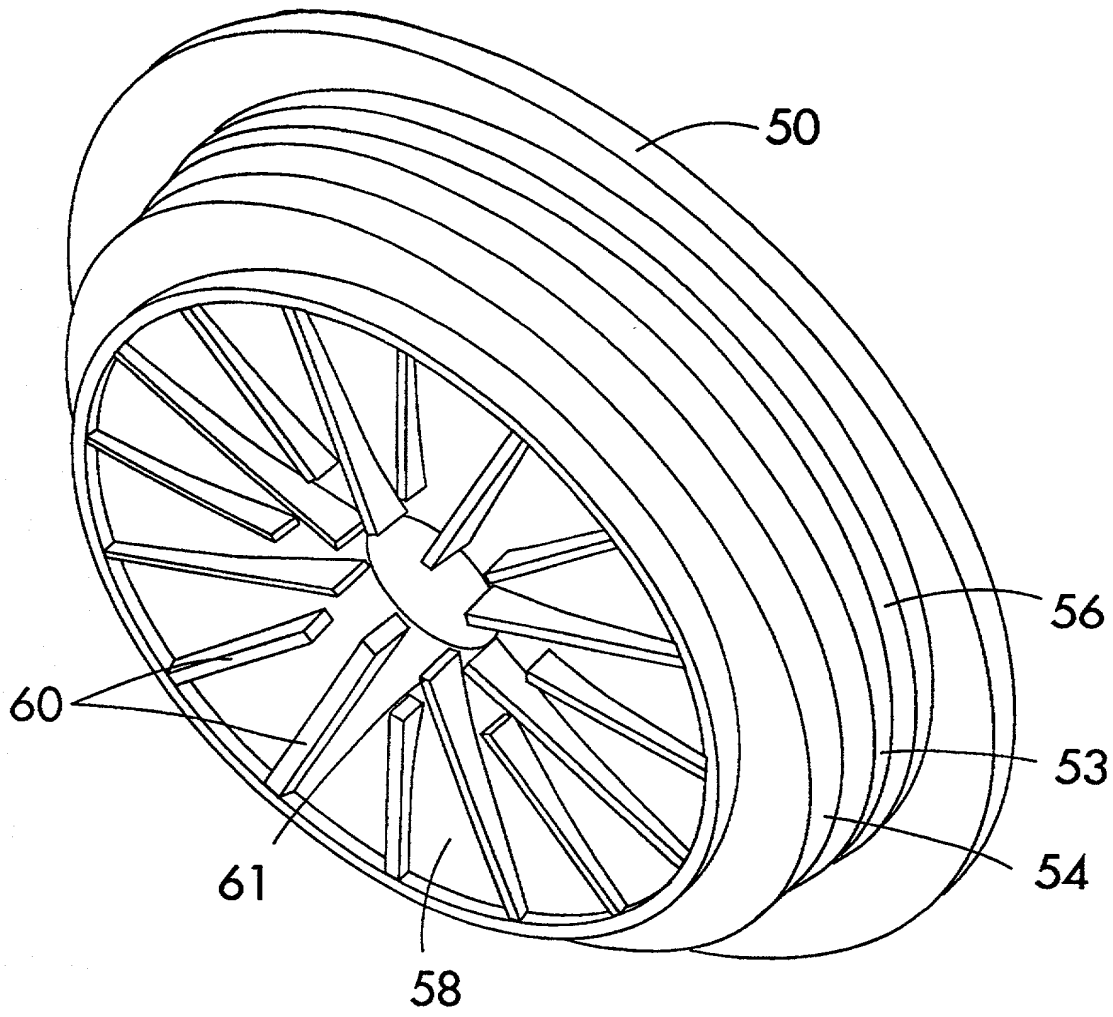


Figure 4

09/913977

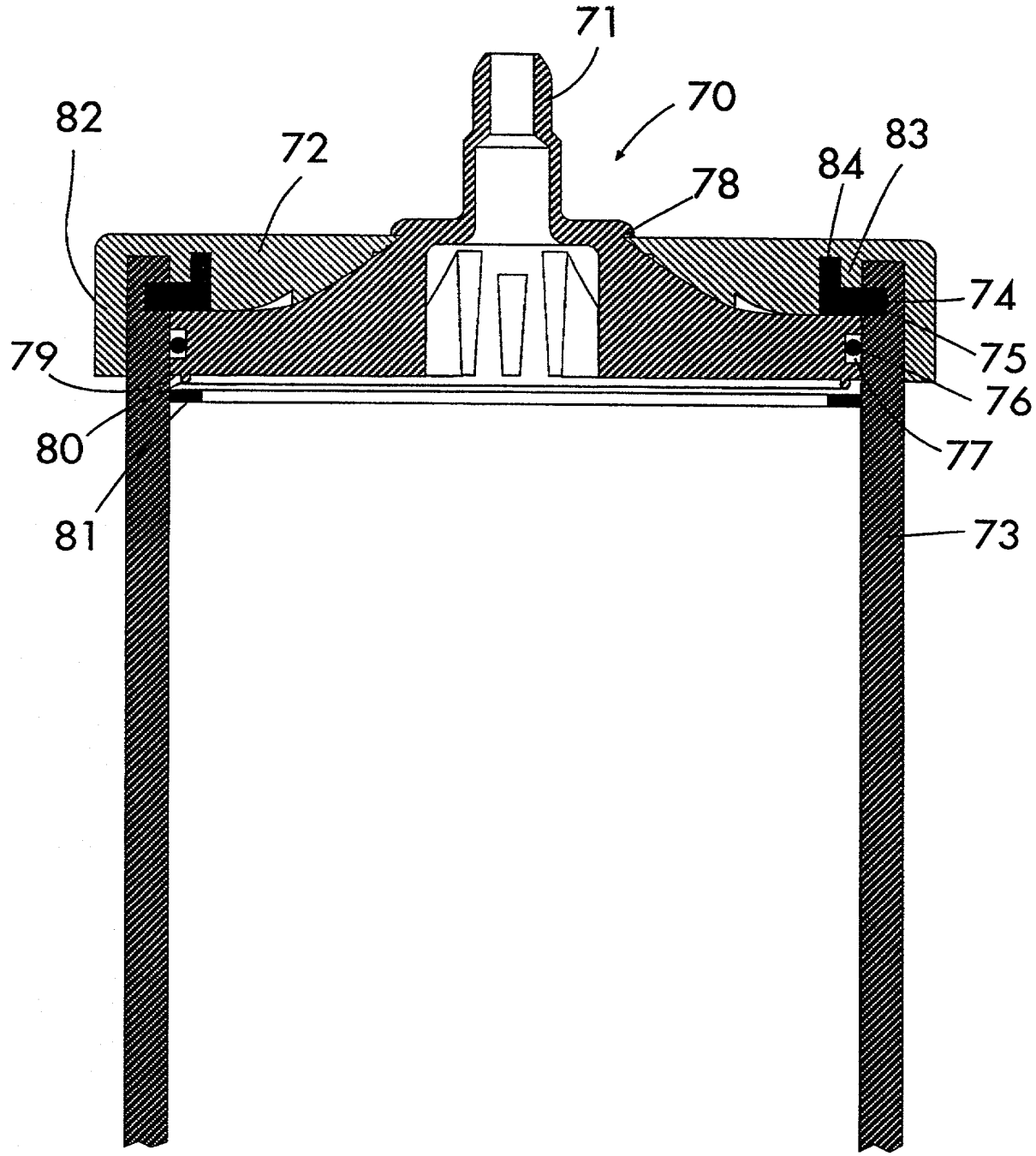


Figure 5

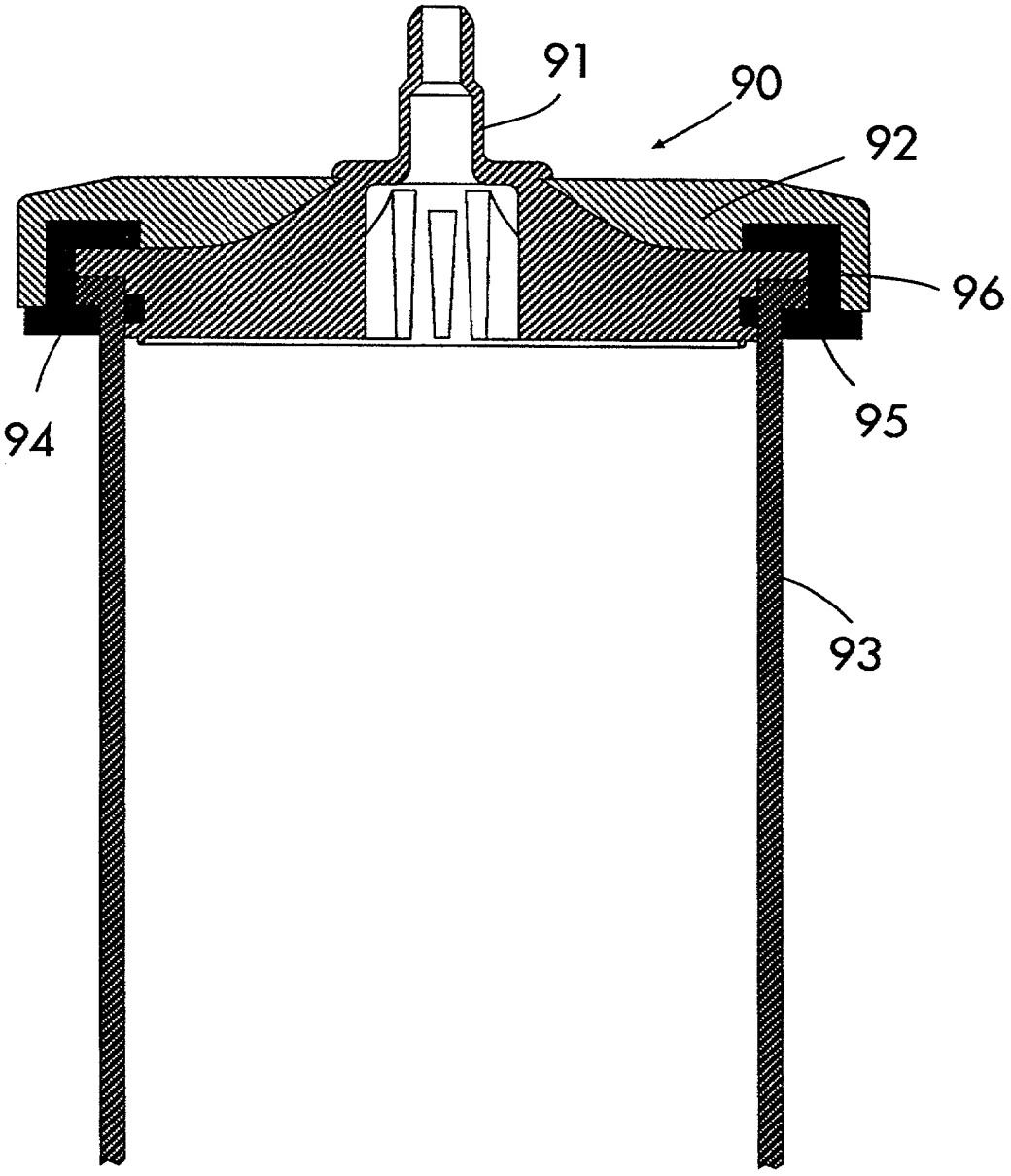


Figure 6

09/914977
09/913977
PCT/US99/28501

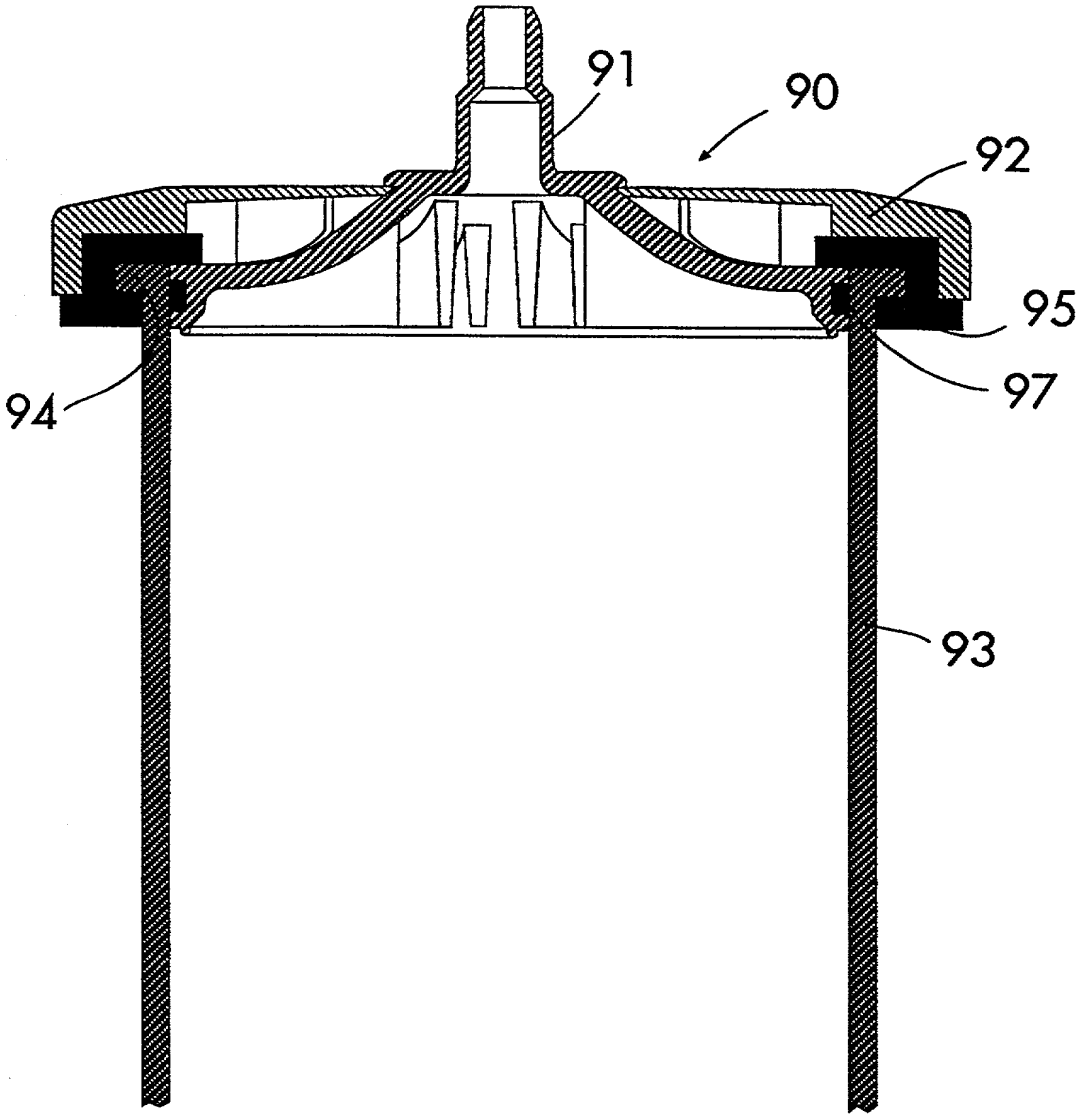


Figure 7

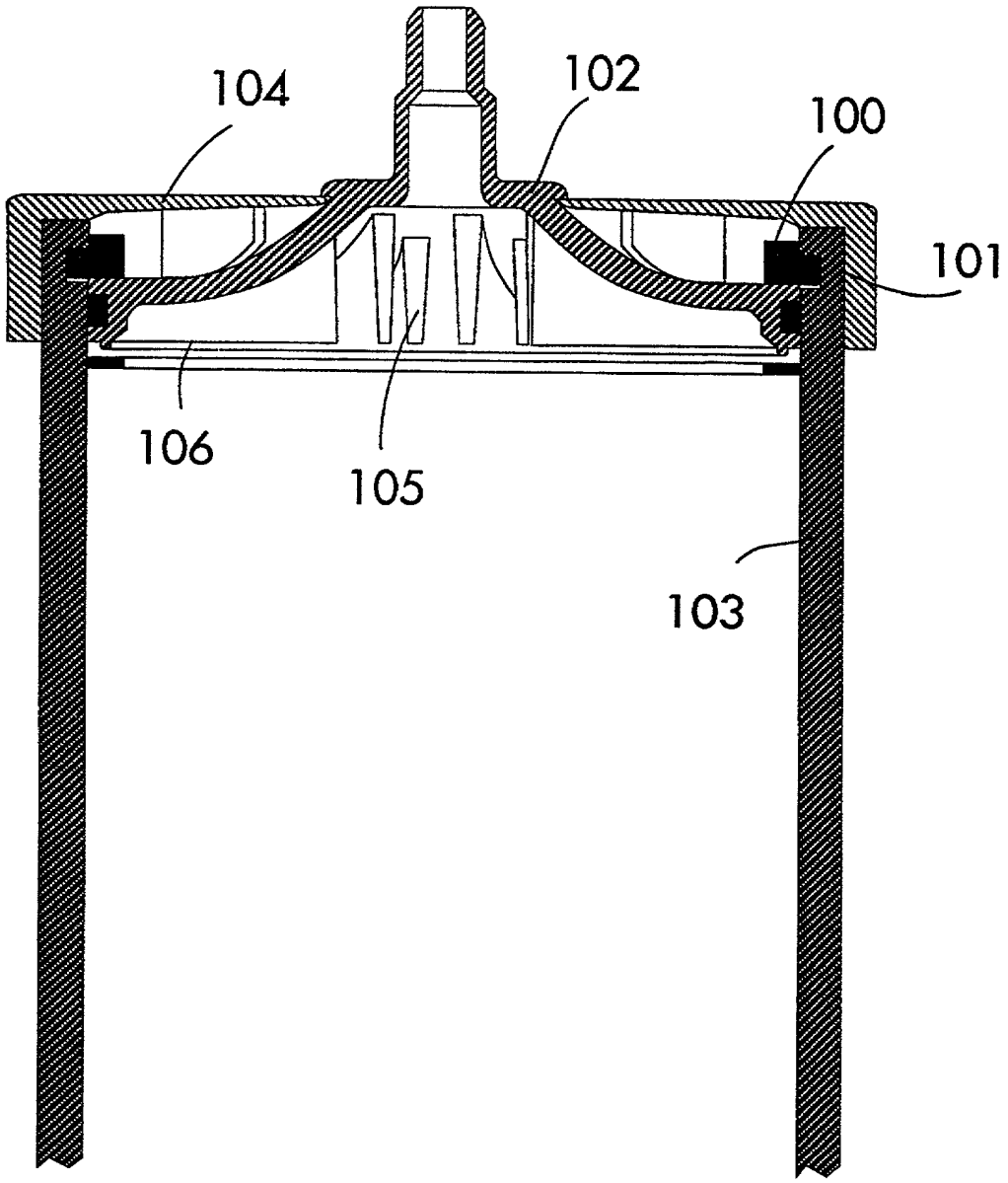


Figure 8

09/913977

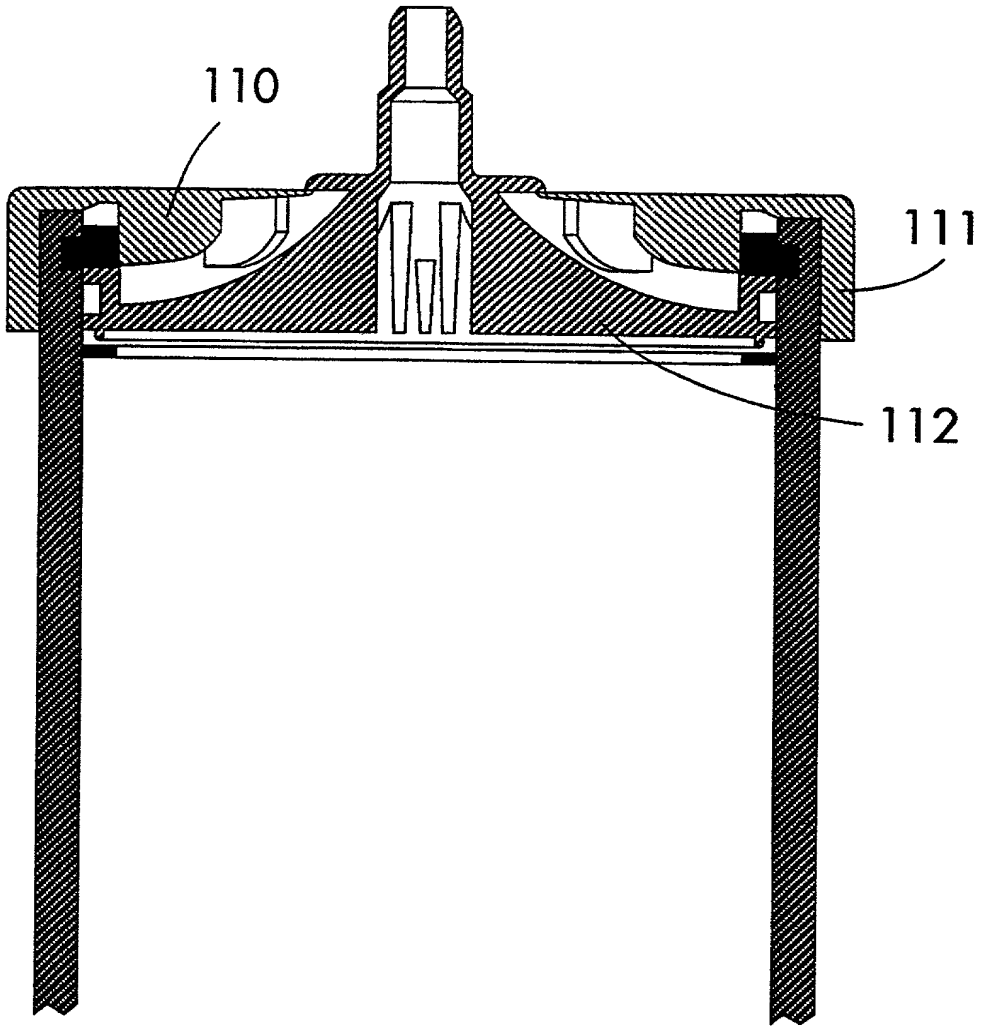


Figure 9

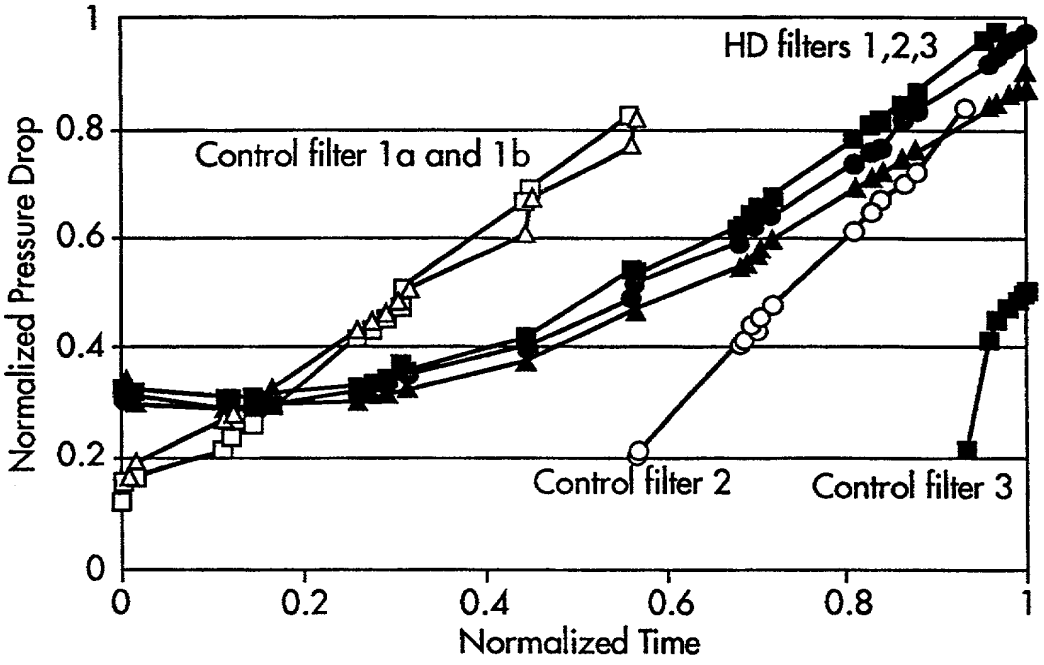

HD filters 1,2,3
Control filter 1a and 1b
Control filter 2
Control filter 3
Normalized Pressure Drop
Normalized Time
0
0.2
0.4
0.6
0.8
1

Figure 10

Declaration and Power of Attorney for Patent Application
English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"FILTRATION CARTRIDGE AND PROCESS FOR FILTERING A SLURRY"

the specification of which

(check one)

[ ] is attached hereto.
[x] was filed on 02 December 1999 as United States Application No. or PCT Application No. PCT/US99/28501
and was amended on December 5, 2000
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
(Number)	(Country)	(Day/Month/Year Filed)	[ ]
(Number)	(Country)	(Day/Month/Year Filed)	[ ]
(Number)	(Country)	(Day/Month/Year Filed)	[ ]

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
60/110,773	03 December 1998
60/132,974	07 May 1999

I hereby claim the benefit under 35 U.S.C. Section 120 of the United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark office all information known to me to be material to patentability as defined in Title 37, C.F.C., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
PCT/US99/28501	02 December 1999	Pending

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Declaration and Power of Attorney for Patent Application
English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"FILTRATION CARTRIDGE AND PROCESS FOR FILTERING A SLURRY"

the specification of which

(check one)

[ ] is attached hereto.
[x] was filed on 02 December 1999 as United States Application No. or PCT Application No. PCT/US99/28501
and was amended on December 5, 2000
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
(Number)	(Country)	(Day/Month/Year Filed)	[ ]
(Number)	(Country)	(Day/Month/Year Filed)	[ ]
(Number)	(Country)	(Day/Month/Year Filed)	[ ]

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

60/110,773 (Application Serial No.)	03 December 1998 (Filing Date)
60/132,974 (Application Serial No.)	07 May 1999 (Filing Date)
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U.S.C. Section 120 of the United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark office all information known to me to be material to patentability as defined in Title 37, C.F.C., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

PCT/US99/28501 (Application Serial No.)	02 December 1999 (Filing Date)	Pending (Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Timothy J. King	Reg. No. 38,204
Paul J. Cook	Reg. No. 20,820

Send Correspondence to:

Timothy J. King, Esq.
Mykrolis Corporation
One Patriots Park
Bedford, Massachusetts 01730
USA

Direct Telephone Calls to:
(name and telephone number)

Timothy J. King, Esq.
Telephone: (781) 533-2522
Facsimile: (781) 533-3125

Full name of first inventor, if any Stephen PROULX	
First inventor's signature	Date:
Residence Boxboro, Massachusetts 01719	
Citizenship United States	
Post Office Address 59 Liberty Square, Boxboro, Massachusetts 01719	

Full name of second inventor, if any George PERIVOLOTIS	
Second inventor's signature	Date:
Residence Littleton, Massachusetts 01460	
Citizenship United States	
Post Office Address Four Bridal Path, Littleton, Massachusetts 01460	

Full name of third inventor, if any
Zhenwu LIN

Third inventor's signature	Date: 8/3/2001

Residence
8F, #9, Lane 81, ChungShan N. Rd, Sec 7, Taipei, Taiwan

Citizenship
USA

Post Office Address

Full name of fourth inventor, if any
Gregory STRAEFFER

Fourth inventor's signature	Date:

Residence
North Chelmsford, Massachusetts 01863

Citizenship
US

Post Office Address
Five Barry Drive, North Chelmsford, Massachusetts 01863

Full name of fifth inventor, if any
George A. GAGNE

Fifth inventor's signature	Date:

Residence
Dracut, Massachusetts 01826

Citizenship
US

Post Office Address
685 Hildreth Street, Dracut, Massachusetts 01826

Full name of six inventor, if any Kenneth KING	
Sixth inventor's signature	Date:
Residence West Newbury, Massachusetts 01985	
Citizenship US	
Post Office Address 12 Newell Farm Drive, West Newbury, Massachusetts 01985	

Full name of seventh inventor, if any Ralph J. STANKOWSKI	
Seventh inventor's signature	Date:
Residence Westford, Massachusetts 01886	
Citizenship US	
Post Office Address 18 Boutwell Hill, Westford, Massachusetts 01886	

Declaration and Power of Attorney for Patent Application
English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"FILTRATION CARTRIDGE AND PROCESS FOR FILTERING A SLURRY"

the specification of which

(check one)

[ ] is attached hereto.
[x] was filed on 02 December 1999 as United States Application No. or PCT Application No. PCT/US99/28501
and was amended on December 5, 2000
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
(Number)	(Country)	(Day/Month/Year Filed)	[ ]
(Number)	(Country)	(Day/Month/Year Filed)	[ ]
(Number)	(Country)	(Day/Month/Year Filed)	[ ]

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
60/110,773	03 December 1998
60/132,974	07 May 1999

I hereby claim the benefit under 35 U.S.C. Section 120 of the United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark office all information known to me to be material to patentability as defined in Title 37, C.F.C., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
PCT/US99/28501	02 December 1999	Pending

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Timothy J. King Reg. No. 38,204
Paul J. Cook Reg. No. 20,820

Send Correspondence to:

Timothy J. King, Esq.
Mykrolis Corporation
One Patriots Park
Bedford, Massachusetts 01730
USA

Direct Telephone Calls to:
(name and telephone number)

Timothy J. King, Esq.
Telephone: (781) 533-2522
Facsimile: (781) 533-3125

Full name of first inventor, if any Stephen PROULX	
First inventor's signature	Date:
Residence Boxboro, Massachusetts 01719	
Citizenship United States	
Post Office Address 59 Liberty Square, Boxboro, Massachusetts 01719	

Full name of second inventor, if any George PERIVOLOTIS	
Second inventor's signature	Date:
Residence Littleton, Massachusetts 01460	
Citizenship United States	
Post Office Address Four Bridal Path, Littleton, Massachusetts 01460	

Full name of third inventor, if any Zhenwu LIN	
Third inventor's signature	Date:
Residence Taipei, Taiwan	
Citizenship	
Post Office Address 8F, #9, Lane 81, ChungShan N. Rd, Sec. 7	

Full name of fourth inventor, if any Gregory STRAEFFER	
Fourth inventor's signature	Date:
Residence North Chelmsford, Massachusetts 01863	
Citizenship US	
Post Office Address Five Barry Drive, North Chelmsford, Massachusetts 01863	

Full name of fifth inventor, if any George A. GAGNE	
Fifth inventor's signature	Date:
Residence Dracut, Massachusetts 01826	
Citizenship US	
Post Office Address 685 Hildreth Street, Dracut, Massachusetts 01826	

Full name of six inventor, if any Kenneth KING	
Sixth inventor's signature Kenneth King	Date: 8-02-01
Residence West Newbury, Massachusetts 01985	
Citizenship US	
Post Office Address 12 Newell Farm Drive, West Newbury, Massachusetts 01985	

Full name of seventh inventor, if any Ralph J. STANKOWSKI	
Seventh inventor's signature	Date:
Residence Westford, Massachusetts 01886	
Citizenship US	
Post Office Address 18 Boutwell Hill, Westford, Massachusetts 01886	

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Timothy J. King Reg. No. 38,204
Paul J. Cook Reg. No. 20,820

Send Correspondence to:

Timothy J. King, Esq.
Mykrolis Corporation
One Patriots Park
Bedford, Massachusetts 01730
USA

Direct Telephone Calls to:
(name and telephone number)

Timothy J. King, Esq.
Telephone: (781) 533-2522
Facsimile: (781) 533-3125

Full name of first inventor, if any Stephen PROULX	
First inventor's signature	Date: 8-3-01
Residence Boxboro, Massachusetts 01719 MA	
Citizenship United States	
Post Office Address 59 Liberty Square, Boxboro, Massachusetts 01719	

Full name of second inventor, if any George PERIVOLOTIS	
Second inventor's signature	Date: 8.3.01
Residence Littleton, Massachusetts 01460 MA	
Citizenship United States	
Post Office Address Four Bridal Path, Littleton, Massachusetts 01460	

3.00

Full name of third inventor, if any Zhenwu LIN	
Third inventor's signature	Date:
Residence Taipei, Taiwan	
Citizenship	
Post Office Address 8F, #9, Lane 81, ChungShan N. Rd, Sec. 7	

4.00

Full name of fourth inventor, if any Gregory STRAEFFER	
Fourth inventor's signature Greg Straeffer	Date: 8/2/01
Residence North Chelmsford, Massachusetts 01863 MA	
Citizenship US	
Post Office Address Five Barry Drive, North Chelmsford, Massachusetts 01863	

5.00

Full name of fifth inventor, if any George A. GAGNE	
Fifth inventor's signature George A. Gagne Jr	Date: 8/8/01
Residence Dracut, Massachusetts 01826 MA	
Citizenship US	
Post Office Address 685 Hildreth Street, Dracut, Massachusetts 01826	

Full name of six inventor, if any Kenneth KING
Sixth inventor's signature — Date:
Residence West Newbury, Massachusetts 01985 MH
Citizenship US
Post Office Address 12 Newell Farm Drive, West Newbury, Massachusetts 01985

Full name of seventh inventor, if any Ralph J. STANKOWSKI
Seventh inventor's signature — Date: 8/28/01
Residence Westford, Massachusetts 01886 MH
Citizenship US
Post Office Address 18 Boutwell Hill, Westford, Massachusetts 01886